LARVAE OF NEOTROPICAL COLEOPTERA XXI: DESCRIPTION OF IMMATURES AND ECOLOGY OF *EFFLAGITATUS FREUDEI* PACHECO, 1973 (DRYOPOIDEA, HETEROCERIDAE)

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ABSTRACT

Immatures of *Efflagitatus freudei* Pacheco, 1973, a southern South American species, known from Uruguay and Brazil (Rio Grande do Sul and São Paulo), are described and illustrated for the first time. A redescription of the adult is presented. Larvae and adults burrow tunnels just beneath the surface in the upper supralittoral region of sandy beaches.

KEYWORDS. Coleoptera larva, Dryopoidea, *Efflagitatus freudei*, Heteroceridae.

INTRODUCTION

The Heteroceridae, according to LAWRENCE (1991:404), "is a small family about 15 genera and 300 species worldwide, except for New Zealand". There are a few papers dealing with the biology, ecology and descriptions of immatures of this family. The three best works on this subject are GWYNN-SILVEY (1935) who described the immatures of *Heterocerus auromicans* = *Centuriatus auromicans* (Kiesenwetter, 1851), from the USA, PIERRE (1945) characterizing the larva of *Heterocerus aragonicus* Kiesenwetter, 1850, from Europe, and KAUFMANN & STANSLY (1979) who studied the bionomics of the Neartic *Neoheterocerus pallidus* (Say, 1823).

The genus *Efflagitatus* Pacheco, 1964 with 13 known species occurs mainly in the Neotropical Region, from Florida (USA) to Argentina. Biological data and immatures were unknown up to date.

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MATERIAL AND TECHNICS

Eggs, larvae, pupae and adults of *Efflagitatus freudei* Pacheco, 1973, were collected in the beaches of Cassino, Rio Grande, Rio Grande do Sul and of Pernambuco, Guarujá, São Paulo, Brazil and are deposited in the Museu de Zoologia, Universidade de São Paulo (MZSP).

Larvae were mounted in metal stubs,coated with gold, and examined at the "Laboratório de Microscopia Eletrônica, Instituto de Biociências, Universidade de São Paulo", with a scanning Electron Microscope (SEM) Zeiss, Model DSM 940, working at 10 Kv.

Efflagitatus freudei Pacheco, 1973

(Figs.1-33)

Efflagitatus freudei PACHECO, 1973: 13, figs. 1-9. Male holotype from Torres, State of Rio Grande do Sul, Brazil, in the Zoologische Staatssammlung Entomologische Abteilung, München.

Mature larva (figs. 10-33). Length 7.0 mm; larger width: 0,9 mm. Head and thorax slightly dorso-ventrally flattened, abdominal segments cylindrical, general appearance campodeiform. Dorsal surface of head and dorsal plates on body, dark-brown with vestiture of short and long setae; head, thorax and the fourth first abdominal segments with denser short setae; abdominal segments fifth to ninth with longer bristly setae; tenth segment small, ventral, pygopod-like.

Head (figs.19,20) broad, protracted and prognathous, slightly dorso-ventrally flattened, covered by dense small setae and a few longer setae. Epicranial suture present, epicranial stem absent, frontal arms U-shaped. Endocarina absent. Five stemmata on each side, forming a group of four placed more dorso-laterally, separated from the remaining stemma ventrally located; lens well developed. Frontoclypeal suture present; clypeus small, membranous with a basal row of 15 setae; labrum free, transverse (fig. 21), outer margin rounded, densely hairy,distal region not pigmented. Epipharynx (fig. 22), densely asperate except on longitudinal median area, anterior median area with a group of micro sensilla. Mandibles (figs. 18, 25-29) symmetrical, bidentate at apex; mesal region concave (fig. 26) with two lateral rows of projected translucent spines bearing small tubercles between them (fig. 28); forming a pseudomola, divided into three regions (figs. 27-29) and bearing a long, stout seta at its base (figs. 18, 29). Antennae (figs. 15, 24) 3-segmented, very short, second segment bearing a large, flattened sensorium, longer than reduced third segment. Ventral mouthparts retracted, densely hairy (fig. 20). Maxilla with elongate stipites separated at base, cardo small, triangular, at base; maxillary palp 3-segmented (fig. 13), galea broad with long apical setae, lacinia elongate and fixed. Labium with prementum small; ligula short and broad; mentum elongate, sides parallel; postmentum small, quadrangular; labial palps very small, two-segmented. Hypopharyngeal sclerome absent, hypopharyngeal bracon weakly sclerotized (fig. 14). Hypostomal rods present. Ventral epicranial ridges present. Gula present, with one pair of small basal setae, on each side.

Prothorax (figs. 10, 12) with dorsal plate well developed, covered densely by thin hairs and primary long setae on margins; median suture present, connecting with U-shaped epicranial suture anteriorad, recognized by its light coloration; pleural region (fig. 12) membranous, smooth, except for one small, transverse,

hairy plate near procoxae; sternite membranous, smooth, except for one anterior median rounded, small plate with three setae and a group of small setae on each side of this spot; hypopleurum well developed, free on anterior third and projected toward ventral epicranial region. Mesothorax (figs. 10, 12): dorsal plate slightly smaller than prothorax, covered by dense thin hairs and scattered long primary setae; median suture present connecting with that of the prothorax; pleural region with two small, transverse hairy plates near meso-coxae. Metathorax (figs. 10, 12) dorsal plate similar to mesothorax; median suture very short connecting with that of the mesothorax; pleural region with two small setae in an anterior rounded spot, and two small transverse hairy plates near meta-coxae. Legs (figs. 16, 17) 5-segmented, slightly longer from anterior to posterior. Anterior leg fossorial, stout; trochanter and femur densely covered by short and long hairs; tibia with very stout, spatulate setae; tarsungulus broad with a distinct tubercle bearing 1 spatulate seta. Median and posterior legs similiar to the anterior one, but less fossorial, slightly elongate, tarsunguli slender, tubercles less distinct and setae less spatulate.

Abdomen (figs. 10-12); abdominal segment I with a rounded, projected, lateral lobe; segments I-IV with several small scattered setae and a few longer; segments V-IX with variable number of longer setae and a few short ones; segment IX with rounded apex; segment X the smallest, ventral, pygopod-like and with short marginal setae.

Spiracles (figs. 32,33): mesothoracic spiracle irregular-oval; abdominal spiracles 1-8 "annular", with an elongate expansion of the peritreme; spiracular opening elliptical, covered by a thin (finely cribrate?) membrane.

Remarks. It is quite difficult to compare the larvae of *E. freudei* with the known heterocerid larvae, due to the fact that the descriptions are scarce in diagnostic characters. There are a few characters that were misunderstood by former authors and merit to be commented. We considered the concave mesal region of the mandibles with two lateral rows of projected translucent spines bearing small tubercles between them, forming a pseudomola divided into three regions and with a long, stout seta at its base. We do not agree to consider the mandibular spines as a retinaculum, neither the basal seta as a 2-articulated process, as stated by PIERRE (1945). Although the hypopharyngeal sclerome is absent, a weakly sclerotized hypopharyngeal bracon is present.

Since BÖVING & CRAIGHEAD (1931) the heterocerid spiracles are said to be cribriform, of a unique type. We did several preparations to study the spiracles with a scanning Electron Microscope, and in all of them the cribrate plate was not evidenced, even under a magnification of 10.000 times. The spiracles have an elongate expansion of the peritreme, and an elliptical spiracular opening, covered by a thin membrane.

Pupa (fig. 23). Length 3.8mm. Elongate-oval, whitish, exarate. Densely hairy, with short and long bristly, brownish setae. Head not visible from above. Pronotum transverse, about 2.2 times as wide as long; anterior margin very arched. Pterothecae hairy, closely apressed to body, extended posteriorly to third abdominal segment. Legs glabrous. Abdominal segments 1 to 7 with a transverse row of 6 long setae; segment 8 with 2 long setae; last abdominal segment with a pair of apical projections.

Adult (figs. 1-9). Length 3.4-4.2mm; width 1.2-1.5mm.

Color. Head dark brown, antennae yellowish-brown, darkened in apical third or half. Pronotum dark brown, with a narrow margin yellowish-brown. Elytra creamy-yellow to yellowish-brown, with dark brown marks, very variable in shape; in some specimens, elytral pattern blurred, marks diffusely limited.

Head with abundant whitish setiform hairs. Labrum (fig.3) with 6 long setiform setae; anterior margin of hypopharynx bearing 8 spatulate sensillae. Antennae (fig.4). Mandible (fig.5) broad, about 1,5 x as long as wide; outer margin with 11 longer setae and 7 smaller and slender, inserted among the anterior ones; incisive area of inner margin with 2 teeth; prostheca notch well defined. Maxilla (fig. 2), galea rounded, with a dense brush of curved setiform hairs. Labium (fig. 6).

Thorax. Pronotum pubescent, hairs whitish, setiform, longer near anterior and posterior angles. Elytra about 1,5 x as long as wide, bearing very short, whitish, recumbent setae. Protibiae with 8 stout spines, meso-and metatibiae with 7 stout spines.

Underside. Post-mesocoxal lines absent. Stridulatory ridge well defined, anterior grooves easily visible under stereomicroscope (50 x).

Male genitalia (figs. 7-9) well sclerotized specially lateral arms of phallobase; parameres well defined; endophallus bearing a well sclerotized, slender, dark sclerite, Y-shaped at apex.

Sexual dimorphism. Males much shorter and more compact than females.

Material examined. BRAZIL. **São Paulo**: Guarujá, Pernambuco beach, 245 eggs; 565 larvae; 59 pupae and 343 adults associated together, Exp. MZSP col., 08.XI.1993 (MZSP); 13 adults, 18 larvae, R. Shimizu col., 5.IV.1993 (MZSP). **Rio Grande do Sul**: Rio Grande, 28km S. Cassino beach, 04 larvae, N.Gianuca col., 01-02.III.1987 (MZSP); 18 adults, 17.X.1989 (MZSP); 71 larvae, 01 pupa and 26 adults, 08.VIII-26.XII.1990 (MZSP); 63 eggs, 52 larvae, 07 pupae, 104 adults, 08.VII-20.XI.1992 (MZSP); 47 first instar larvae and 147 adults, Exp. MZSP col., 8-14.IX.1992 (MZSP); 14 adults, Exp. MZSP col., 12-16.IV.1993 (MZSP).

Remarks. The Brazilian specimens, from Rio Grande, RS and Guarujá, SP, agree very well with Pacheco's descriptions of the species. The structure of the male genitalia is extremely similar (figs. 7-9). In our illustration of the lateral view of the male genitalia (fig. 7) can be seen the sclerite of the endophallus, bifid at apex, not reported in the original description.

Bionomics and Ecological Data. Bionomics and ecological observations were conducted in the extensive southern Brazilian beach of Cassino (32° 14'S, 52° 10'W) and complementarily, in the beach of Guarujá (24° 00'S, 46° 22'W).

It was found that the distribution of *E.freudei* is restricted to the upper part of the evenly sloping sandy beaches. There, on the borders of freshwater streams, that drain marshes and ponds located behind the coastal dunes, these insects construct very characteristic tunnels just beneath the surface of the sand (fig. 34). During rainy periods their distribution can extend to the supratidal zone and other parts of the beach saturated with freshwater. In the dry season, when the water in the streams begins to drop, they concentrate in the few remaining moist sands. However, these heterocerids avoid saltwater and, on occasions, when the complete beach is covered by stormy seas, the adult population migrates to wet slacks protected from wave action by the foredunes.

Adults and larvae appear to feed upon organic detritus and microscopic psammic algae and associated protozoans that inhabit the top layer of the substrate. Samples taken in places where the highest population densities were found, revealed the presence of large numbers of different species of algae. The dominant forms were the diatoms *Navicula capitata, Caloneis brevis, Mastogloia exigua, Hantzschia virgata, Petroneis humerosa, Navicula* spp., *Diploneis* sp., *Nitzschia* sp., and the blue-green *Oscillatoria nigroviridis*. The same samples contained a great number of protozoans, with a clear dominance of microporal ciliates. In that area where the heterocerids burrow their galleries, the amount of organic detritus, bacteria diatoms and other algae may form a sort of film that often binds the surface particles together and can give peculiar colours to the sand.

In Cassino beach, quantitative samples collected from October, 1989 to October, 1990, have shown that adults and immatures abound throughout the year. Adult densities varied between a minimum of 16 organisms per square meter in the dryer zones and a maximum of 162 org.m^2 near a stream. Observations in the beach of Guarujá, revealed the occurrence of 60 egg clusters, 28 pupae and 40 recently emerged imagos per square meter. The eggs are laid at depths varying from 15 to 30mm and remain together forming typical clusters containing 18 to 32 eggs, with an average of 24,5 per cluster.

Although mating was not observed, reproduction seems to take place almost continuously, resulting in the production of several generations per year. Nocturnal flights, that could be related with the reproductive habits of the species, were recorded in some warm and calm nights. In two occasions, during the Spring, many specimens were collected at night in pitfall traps located more than 30m away from a stream. During the collections in Cassino beach, it was noticed that, when the sand is disturbed the insects start to run and several fly away. Sometimes specimens fall in the water, from where they can fly again directly from the surface. Those that remain for a few seconds are immediately eaten by voracious small fishes.

While hidden in their tunnels, the main predators are shorebirds such as *Charadrius collaris, Calidris fuscicollis* and *Pluvialis dominica*, which probe the sand with their bills to catch them. In daylight, during Spring and Summer, the tiger-beetles, *Cicindela patagonica bergiana*, were seen in great numbers preying upon the heterocerids. Nocturnal predators are represented by the sand toad *Bufo arenarum arenarum* and the frog *Leptodactylus ocellatus*, whose stomach contents revealed many specimens.

Yet in Cassino beach, adults and immatures of other fossorial species are found together with *E. freudei*, constituting a sort of burrowing assemblage characteristic of a limited area around the streams. The most conspicuous are *Paracymus rufocinctus* (Hydrophilidae), *Neotridactylus carbonelli* (Tridactylidae) and *Bembidion* sp. (Carabidae). Further common insects in that assemblage, but whose distribution was found to extend to dryer areas beyond the borders of the streams, are *Bledius bonariensis* and *B. microcephalus* (Staphylinidae) and *Schizogenius costiceps* (Carabidae).

Discussion. The available information regarding the biology and ecology of the 15 genera and about 300 worldwide known species of heterocerids is very

scarce, but different authors agree on their preference to burrow in damp sands and mud flats on the shores of fresh and brackish streams, rivers, lakes and ponds.

Two of the most important biological studies ever published appear to be that of GWYNN-SILVEY (1935), who described the life-history of *Centuriatus auromicans* in the Great Lakes region of USA and that of KAUFMANN & STANSLY (1979) who studied the bionomics of *Neoheterocerus pallidus* in the sandy floodplain of South Canadian River, Oklahoma. Present findings on the egg laying of *E. freudei* can be compared with the observations of GWYNN-SILVEY (1935). In *E. freudei*, eggs are laid at depths from 15 to 30mm in clusters containing an average of 24.5 eggs each, whilst in *C. auromicans* they are laid 25mm beneath the surface varying in number from 10 to 30 per cluster.

There is no agreement among authors regarding the feeding habits. GWYNN-SILVEY (**op. cit.**) has observed adults feeding on phytoplankton that was deposited on the shores, but never on zooplankton or other animal life of any kind. PACHECO (1964) speculates that members of this family, both larvae and adults, are predators of the accompanying fauna. GREEN (1968) mentions that in European estuaries adults and larvae of the genus *Heterocerus* appear to be detritus and algal feeders. PACHECO (1978), in a review of the North American species, mentions that most adults feed on zooplankton, but some are omnivorous. KAUFMANN & STANSLY (1979) observed the larvae *N. pallidus* indiscriminately consuming soft mud during the construction of their galleries, adding that "the food of the adults does not differ from that of larvae". LAWRENCE (1991) believes that the heterocerids "ingest quantities of substrate from which they extract algae, diatoms and other organic material". Current observations in southern Brazilian beaches, suggest that *E. freudei* feeds mainly upon organic detritus, psammic and phytoplanktonic diatoms, deposited on the upper beach, and the associated protozoans.

No previous observations were reported on the predators of heterocerids, apart from the records of BRO-LARSEN (1936), quoted by GREEN (1968), informing that in Denmark the larvae of *Dyschirius* feeds on the eggs of *Heterocerus*. Based on this information, it would be possible to speculate that a similar predation could take place in Cassino beach, with the eggs of *E. freudei* being taken by the larvae of the carabids *Schizogenus costiceps* and *Bembidion* sp.

Quantitative data are algo very scarce in the literature, but the highest population densities recorded during this study (162 m^2) were nearly 10 times higher than the average observed by GWYNN-SILVEY (1935) during the summer of 1929.

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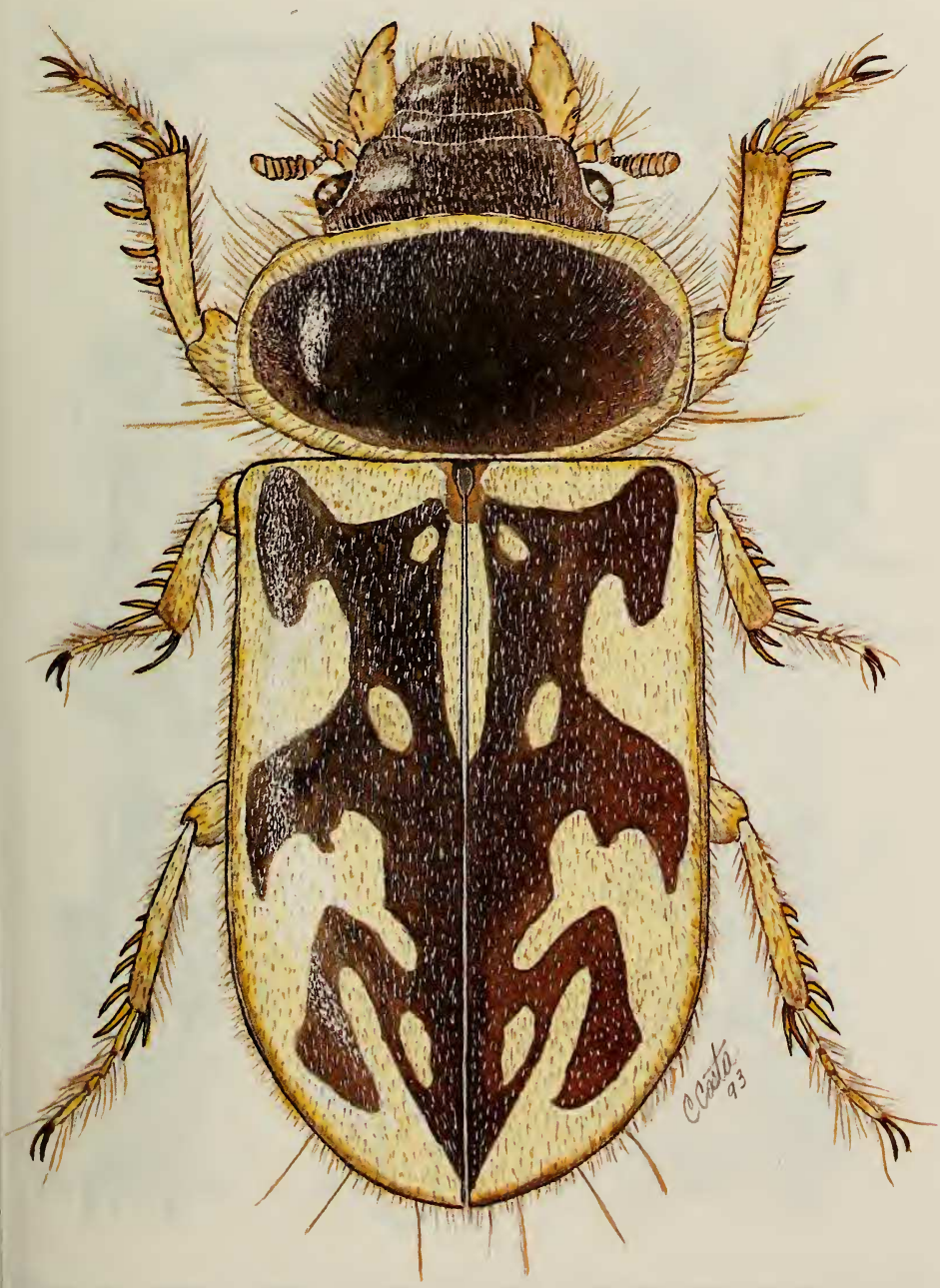
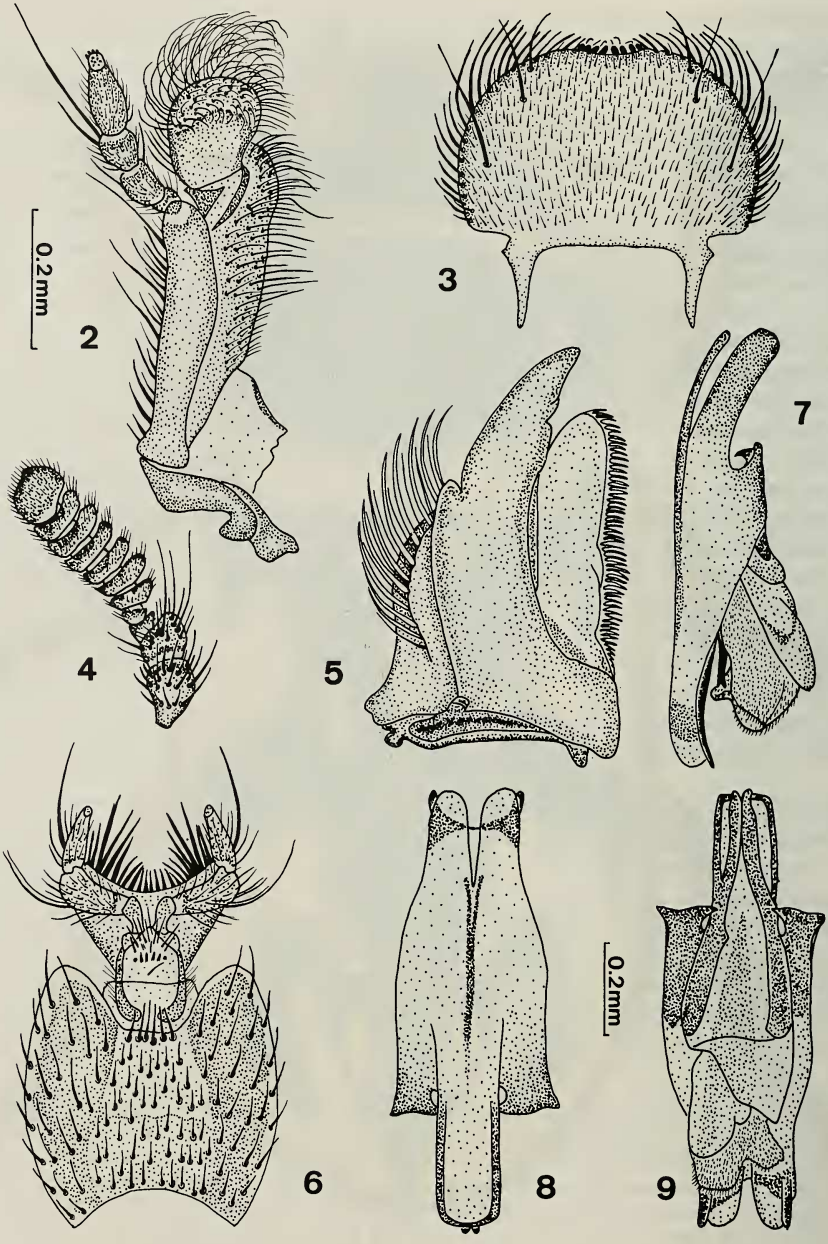
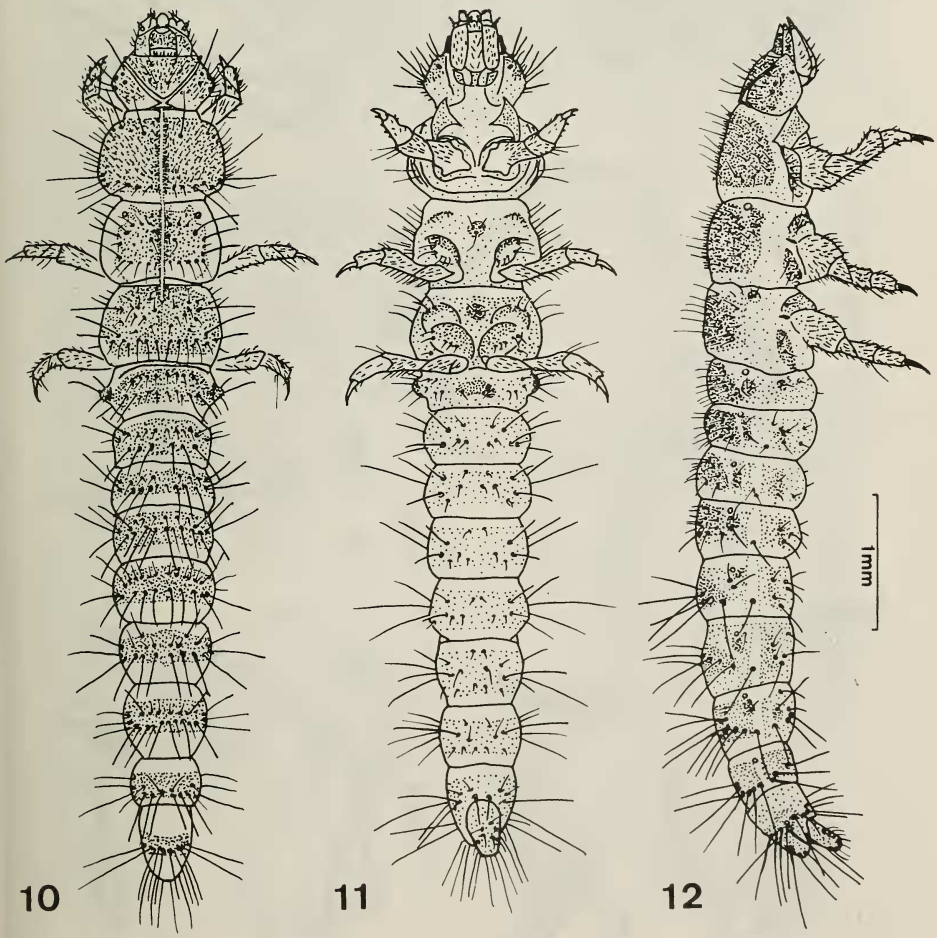


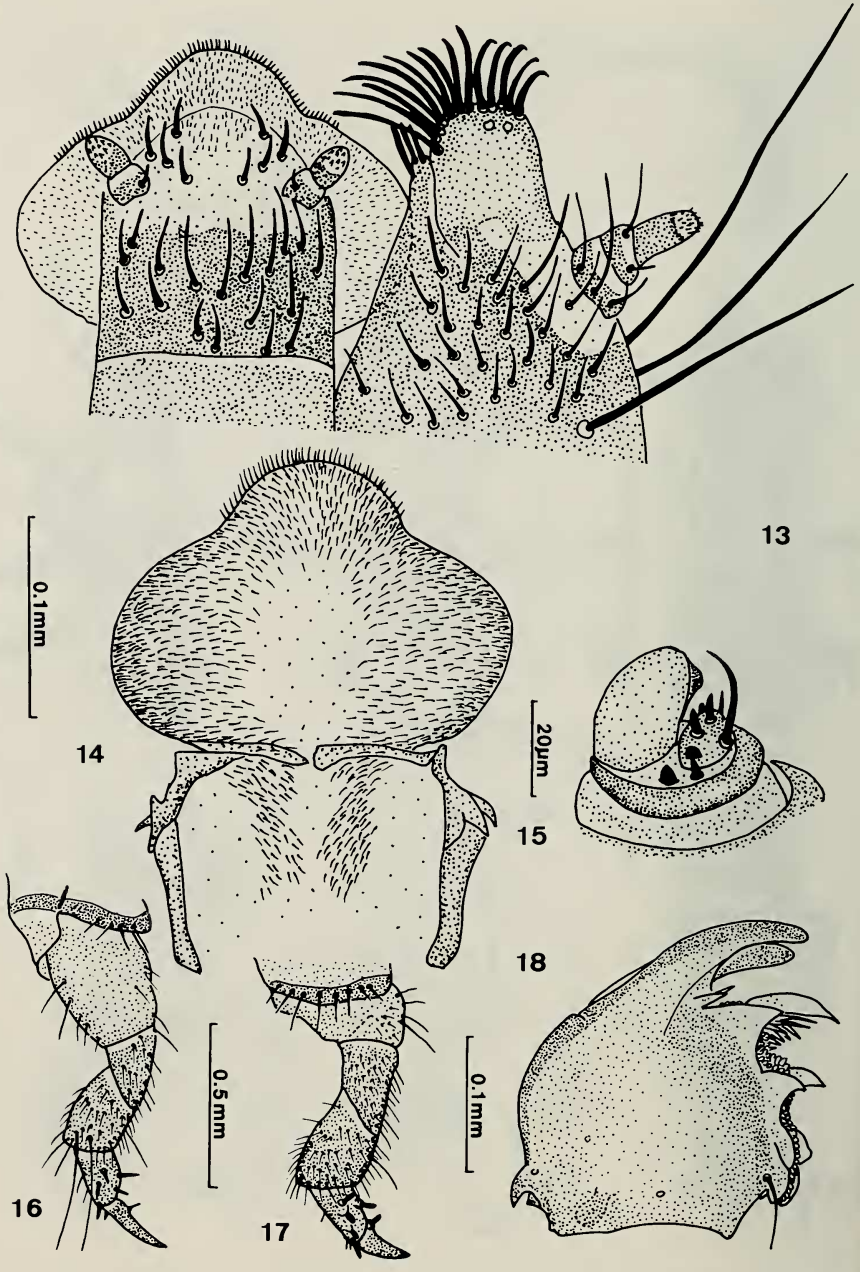
Fig. 1. *Efflagitatus freudei*, female from Rio Grande, RS (lenght: 4.1mm).



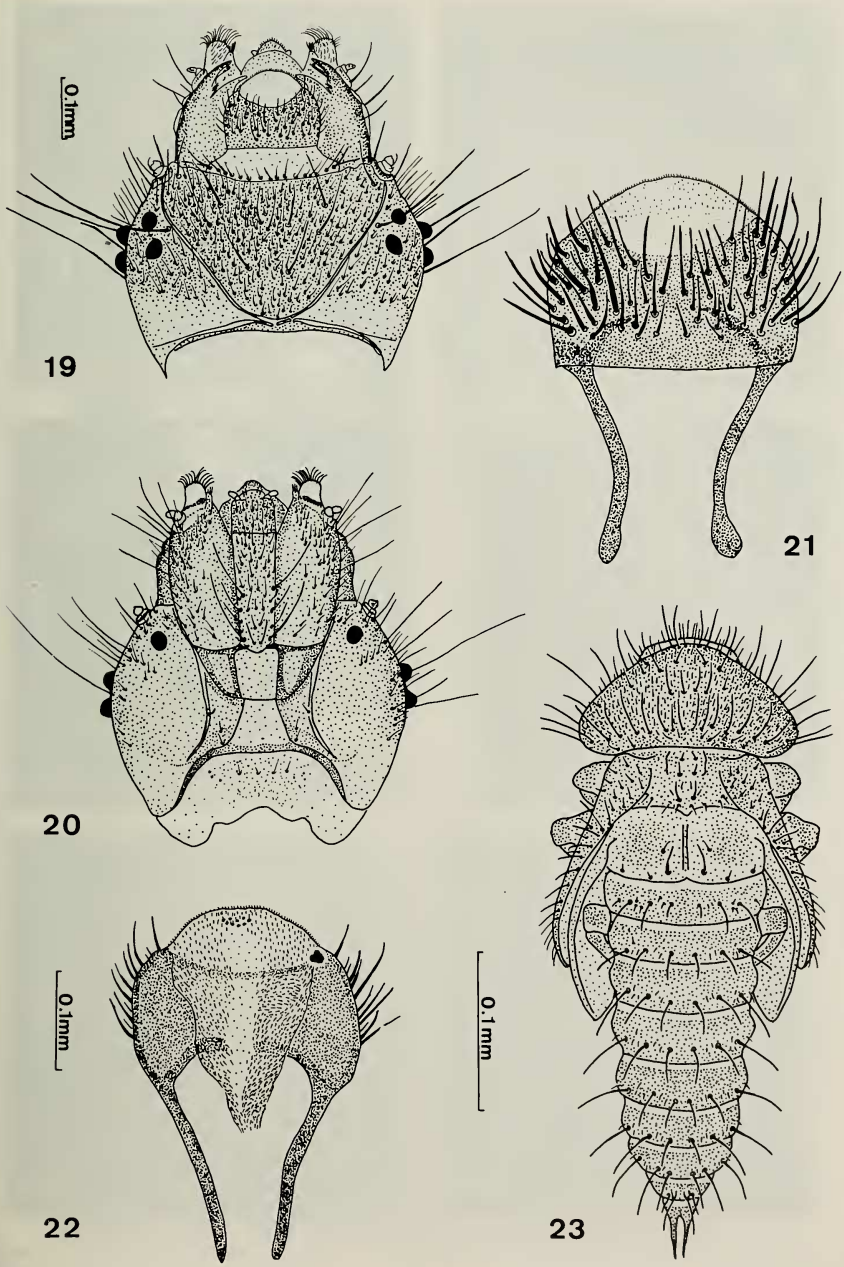
Figs. 2-9. *Efflagitatus freudei,* male from Rio Grande, RS: 2, maxilla; 3, labrum; 4, antenna; 5, left mandible dorsal; 6, labium; 7-9, aedeagus (lateral, dorsal and ventral, respectively). Figs. 2-6; 7-9, respectively, in the same scale.



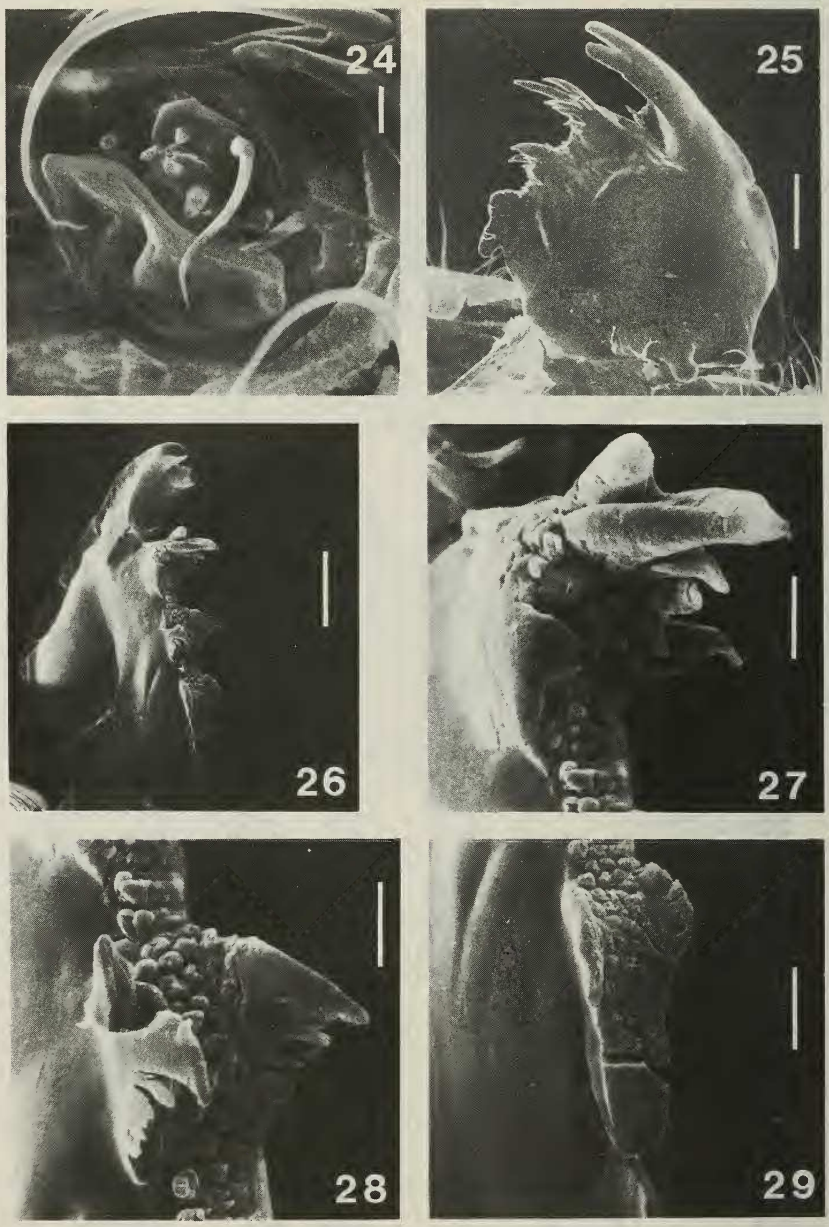
Figs. 10-12. *Efflagitatus freudei*, mature larva from Guarujá, SP (dorsal, ventral and lateral, respectively).



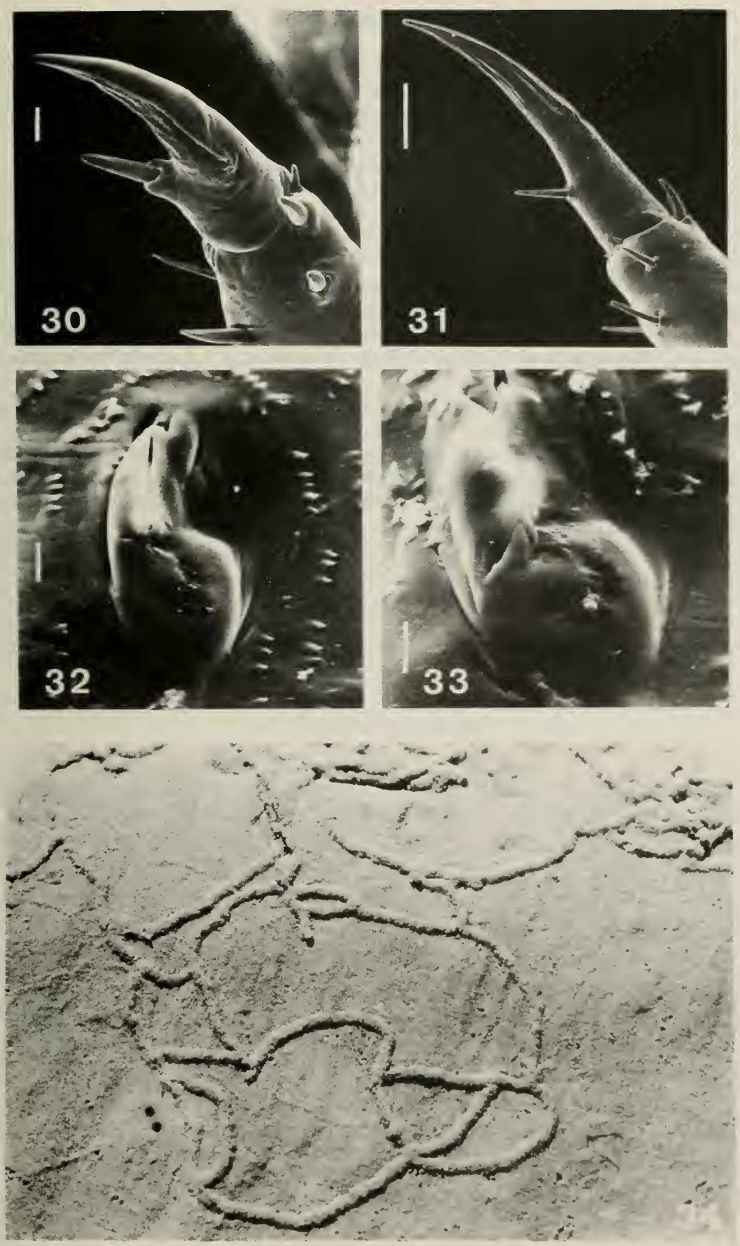
Figs. 13-18. *Efflagitatus freudei*, mature larva from Guarujá, SP: 13, maxilla and labrum; 14, hypopharynx; 15 antenna; 16, median leg; 17, anterior leg; 18, left mandible, dorsal. Figs. 13-14; 16-17, respectively, in the same scale.



Figs. 19-23. *Efflagitatus freudei*. 19-22, mature larva from Guarujá, SP: 19-20, head (dorsal and ventral); 21, labrum; 22, epipharynx. 23, Pupa (dorsal). Figs. 19-20; 21-22, respectively, in the same scale.



Figs. 24-29. *Efflagitatus freudei*, mature larva from Guarujá, SP, scanning electron micrographs: 24, antenna, latero-frontal view, showing the large flattened sensorium, line = 5μm; 25, left mandible, ventral, line = 50μm; 26, left mandible, latero-mesal view, showing concave pseudomola, line = 40μm; 27, detail of upper region of pseudomola, line = 10μm; 28, detail of median region of pseudomola, line = 10μm; 29, detail of posterior region of pseudomola, line = 10μm.



Figs. 30-34. *Efflagitatus freudei*. Mature larva from Guarujá, SP, scanning electron micrographs: 30, tarsungulus of anterior leg, line = 20μm; 31, tarsungulus of median leg, line = 50μm; 32, abdominal spiracle 6, line = 5mm; 33, abdominal spiracle 3, line = 5μm. 34. Tunnels of adults at Cassino beach, Rio Grande, RS.

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